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EVIDENCE OF DEEPWATER SPAWNING OF FALL CHINOOK SALMON (ONCORHYNCHUS TSHAWYTSCHA) SPAWNING NEAR IVES AND PIERCE ISLAND OF THE COLUMBIA RIVER

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Evidence of Deepwater Spawning of Fall Chinook Salmon (*Oncorhynchus tshawytscha*) Spawning near Ives and Pierce Island of the Columbia River, 1999

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Contents

Figures

Tables

Introduction

Fall chinook salmon *Oncorhynchus tshawytscha*, thought to originate from Bonneville Hatchery, were first noted to be spawning downstream of Bonneville Dam by Washington Department of Fisheries and Wildlife (WDFW) biologists in 1993 (Hymer 1997). Known spawning areas include gravel beds on the Washington side of the river near Hamilton Creek and Ives island. Limited spawning ground surveys were conducted in the area around Ives and Pierce Islands during 1994-1997 and based on these surveys it was believed that fall chinook salmon successfully spawned in this area. The size of this population from 1994 to 1996 was estimated at 1,800 to 5,200 fish (Hymer 1997). Recently, chum salmon were also documented spawning downstream of Bonneville Dam. Chum salmon *O. keta* were listed as threatened under the Endangered Species Act (ESA) in March, 1999.

There are several ongoing investigations to define the physical habitat characteristics associated with fall chinook and chum salmon spawning areas downstream of Bonneville Dam. A major concern is to determine what flows (i.e. surface elevations) are necessary to ensure their long-term survival. Our objective was to locate deepwater spawning locations in the main Columbia River channel and to collect additional data on physical habitat parameters at the site. This objective is consistent with the high priority that the Northwest Power Planning Council's Independent Advisory Board and the salmon managers have placed on determining the importance of mainstem habitats to the production of salmon in the Columbia River Basin.

Methods

Underwater video surveys were conducted to document redd characteristics and to map the extent of fall chinook salmon spawning habitat on November 15-16 and December 1-2, 1999. The study area was located downstream of Bonneville Dam at Columbia River km 228.5 (Figure 1). Line transects were established based on the information gathered during spawning surveys completed by the WDFW in 1998. These search zones were then expanded from near shore to deeper water near the main river channel both upstream and downstream of the known spawning area. The primary survey zone was segmented into a series of 30 m transects running perpendicular to the shoreline. Two additional areas outside the primary survey zone were surveyed using a zig-zag search pattern. Visual images of redds and bottom substrate were recorded using an underwater video system according to procedures described in Dauble et al. (1999).

The mobile underwater video system used was composed of a high-sensitivity remote camera (Sony, model HVM-352) attached to a weighted platform. Recordings were made using a Sony model FX710 Hi 8mm recorder located on the survey vessel. Two high-resolution monitors were used during the surveys for better viewing of the video obtained by the remote camera. The location for each image (northing and easting) was correlated to Global Positioning System (GPS) location by a time stamp. An on-board, real-time differential GPS (Trimble Pathfinder™ Pro XR) was used to collect positional data and to navigate a pre-set transect grid during the surveys. The integrated GPS beacon receiver and antenna provided GPS corrections for calculating sub-meter accuracy (approximately 0.5 m) on a second-by-second basis, and thus eliminated the use of a surveyor to capture positional information of the boat during surveys. The system's software (ASPEN) displayed a background map of the study site on a personal computer so researchers could navigate to site locations on a pre-determined transect line and visually verify data accuracy in the field.

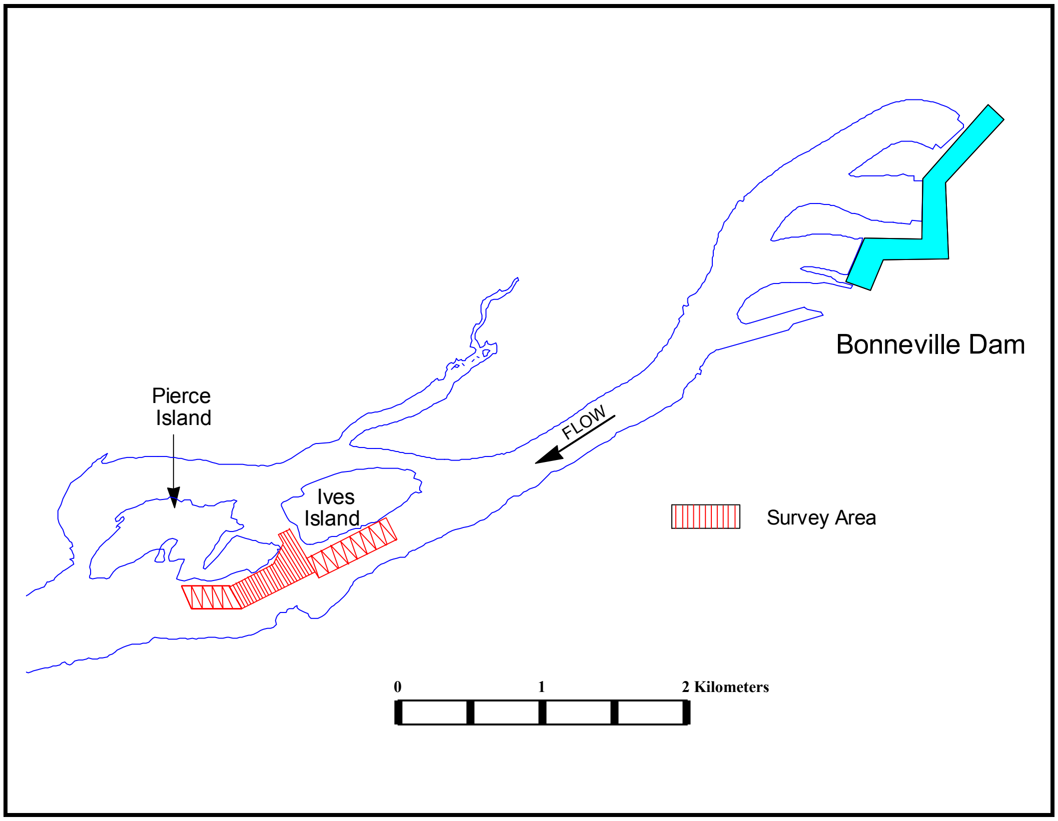


Figure 1. Location of primary search zones in relation to Ives and Pierce Islands

Velocity data was collected using a Marsh McBirney model 2000 flow-meter attached to the camera sled. Turbidity was recorded using a LaMotte model 2008 turbidimeter. Two underwater lasers (C Map Systems model HL6312G), pointed downward 18.4 cm apart, were attached to the underwater platform and provided a reference scale within the camera image for substrate measurements. The distance from the camera lens to the substratum ranged from 0.9 to 1.4 m, providing an effective view path of ~ 2.7 m^2 during low turbidity conditions. Based on existing literature of fall chinook salmon redd areas, we determined that the minimum average size redd to be approximately 10 m^2 (Burner 1951; Chapman 1983; Visser 1999). Based on this value, any redds mapped that fell within a ~ 1.8 m radius of a nearby redd was omitted from the overall redd count. This was done to reduce the probability that a redd would be counted more than once. Changes in background contrast, bed elevation, or substrate composition were the primary criteria used to determine spawning activity. Recorded tapes were reviewed in detail at the Pacific Northwest National Laboratory (PNNL) computer lab using a high-resolution monitor. Bathymeteric data was obtained using a one-dimensional, unsteady river flow and water quality computer model MASS1 (Modular Aquatic Simulation System 1D), developed at PNNL.

The substratum for each redd mapped was estimated using the recorded videotapes and corresponding GPS time stamp. Particle size was determined by taking an average of the dominant and subdominant substrate type at each redd based on long-axis diameter. The substrate size for each redd was classified according to three general size categories (Table 1).

Table 1. Substrate categories used for spawning habitat classification (modified from Platts et al. 1983)

Category	Sediment Classification	Long Axis Diameter of Individual Substrate (cm)
1	Gravel	0.6–7.6
2	Medium cobble	7.6–15.2
3	Large cobble	15.2–30.5

Results

Initial deepwater redd surveys of the main channel near Ives and Pierce islands were completed on November 9-10, 1999 or immediately after the peak spawning date of November 5. Total river flow recorded at Bonneville Dam averaged 143 kcfs during the two-day survey. The surface elevation recorded at staff gauge 1 near Hamilton Cr. averaged 2.46 ft. A total of 50 redds were located in depths ranging from 3.7 – 5.2 m. Twelve additional redds were found between Ives and Pierce islands at depths less than 3.0 m. Redds were generally found in the channel separating Ives and Pierce islands and along the main channel side of Pierce Island. No redds were found near the upper portion of Ives Island or the lower portion of Pierce Island.

The second deepwater fall chinook salmon redd survey was completed on December 1-2, 1999. The survey was limited to the areas where redds were mapped during the initial survey. An estimated 45 additional redds were mapped during the December 1-2 surveys bringing the number of mapped redds to 107 (Figure 2). Flows during the second survey ranged from 185-210 kcfs. The deepest redds found during the December survey was 3.3 m (~2 m when corrected to total river flow of 143 kcfs). The surface elevation recorded at staff gauge 1 averaged 6.5 ft. Turbidity was also higher (6.3 NTU s), which limited the maximum depth for effective observations to ~ 5 m. The majority of the fall chinook redds (69%) were found in depths of 2-4 m (Figure 3).

The dominant and subdominant substrate size was classified for the majority of redds (96) found during the November and December surveys. The dominant substrate consisted predominately (76%) of medium cobbles with the subdominant substrate comprised of about equal proportion of gravel, medium cobble and large cobble (Figure 4).

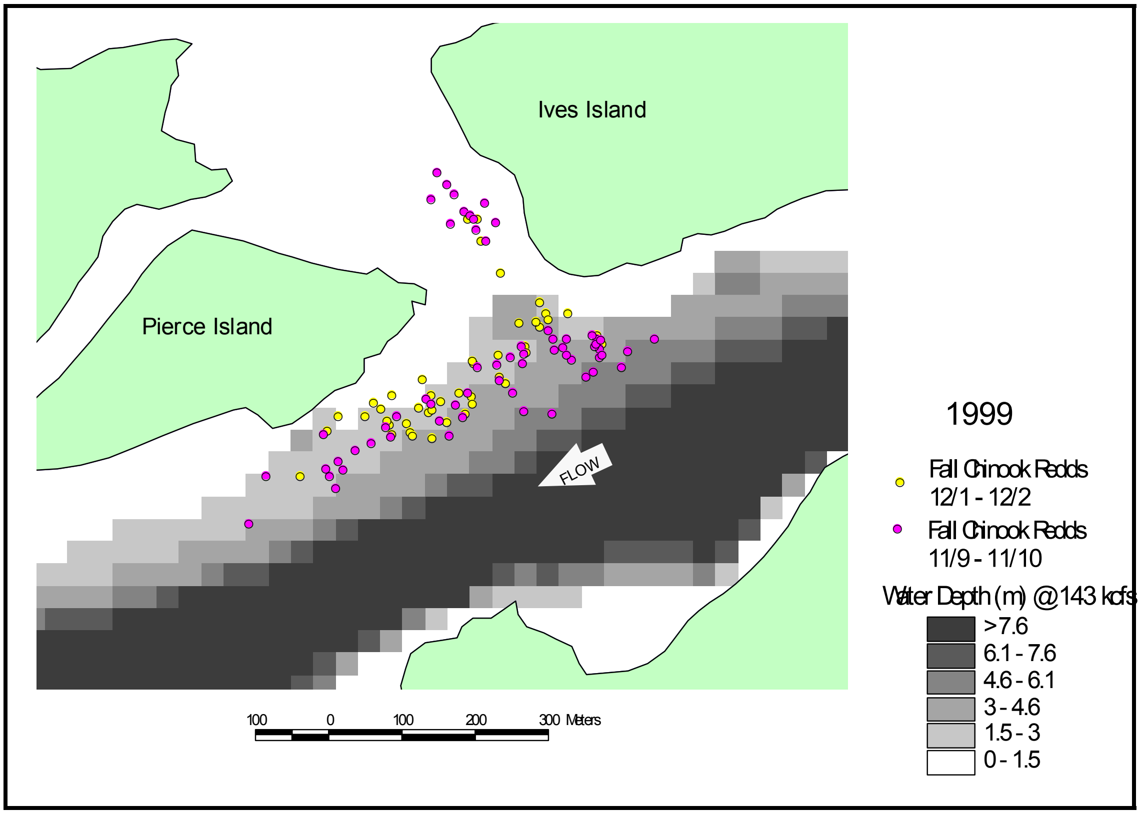


Figure 2. Location of fall chinook salmon redds in the mainstem of the Columbia River below Bonneville Dam, 1999. Note that this map dose not include redds counted by other agencies.

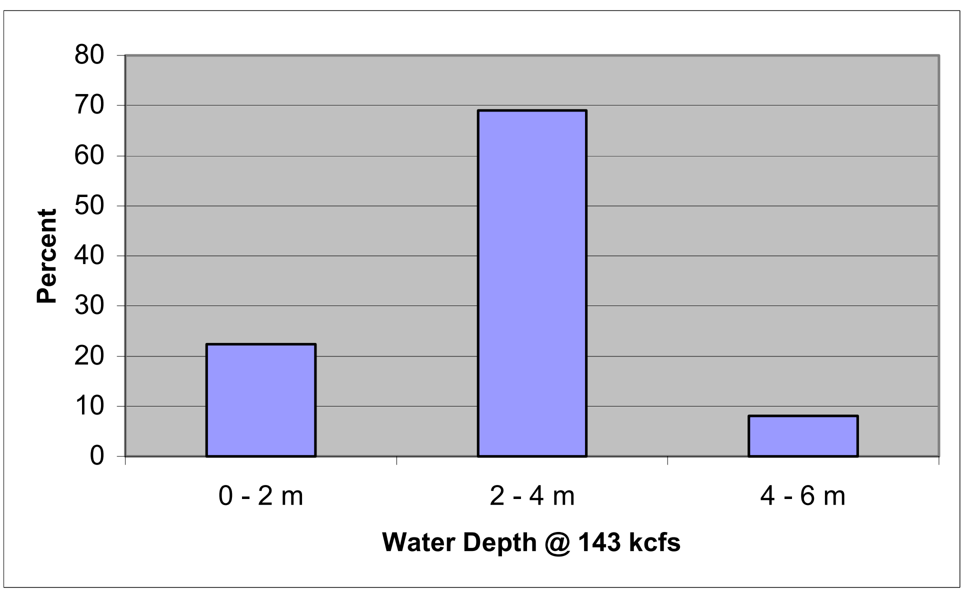
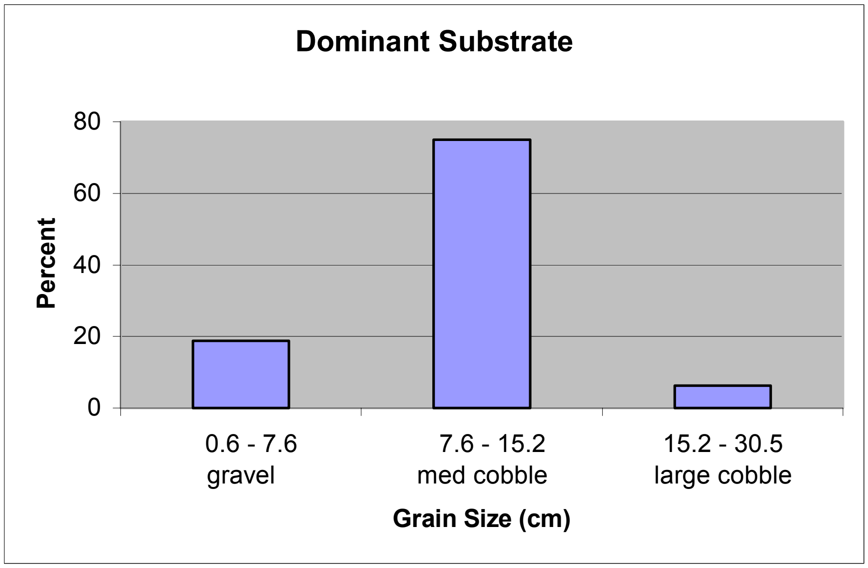


Figure 3. Distribution of fall chinook salmon redds (n= 107) in relation to water depth found during the November and December surveys.



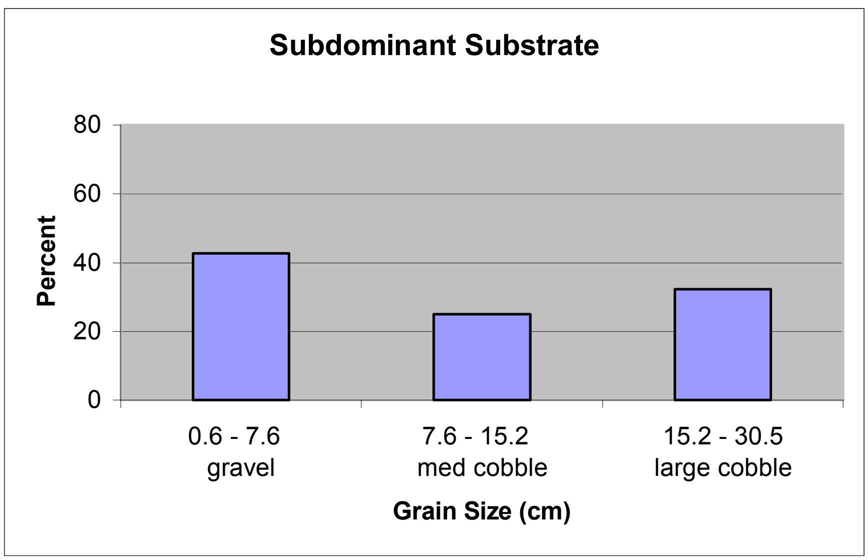


Figure 4. Dominant and subdominant substrate classification (number of redds =96)

Mean near-bed point velocities were obtained at 7 randomly selected redds located in the main river channel south of Pierce Island. The point velocities ranged from 0.54 to 1.23 m/s. These values are similar to point velocities measured near fall chinook salmon redds in the lower Snake River (0.6-1.8 m/s; Dauble et al. 1999), and redds at Vernita Bar in the Hanford Reach (0.45 – 1.95 m/s @ 120 kcfs; Chapman et al. 1993).

Summary

We mapped an estimated 107 redds on surveys conducted in November and December 1999. Spawning activity was concentrated between Ives and Pierce islands and adjacent to Pierce Island in the main river channel. Redds were found to depths of 5.2 m, velocities of 0.5 to 1.2 m/sec, and mainly over cobble substrate. That fall chinook salmon were found spawning in deeper water is not surprising based on surveys in the lower Snake River and Hanford Reach, which documented fall chinook salmon spawning at water depths up to 7.6 m (Dauble et at. 1999; Chapman et al. 1993). The approximate size of the fall chinook spawning area in 1999 mapped by the WDFW was 9.3 ha. Our surveys expanded the known spawning area in 1999 ~ 4.0 ha, to 13.3 ha total (see Appendix B).

References

Burner, C.J. 1951. Characteristics of spawning nests of Columbia River salmon. Fishery Bulletin 61, Volume 52. U.S. Fish and Wildlife Service. Washington, D.C.

Chapman, D.W., D.E. Weitkamp, T.L. Welsh, and T.H. Schaldt. 1983. Effects of minimum flow regimes on fall chinook salmon spawning at Vernita Bar 1978-1982. Don Chapman Consultants, McCall, ID and Parametrix, Inc. Bellevue, WA.

Dauble, D.D., R.P. Mueller, R.L. Johnson, W.V. Mavros, and C.S. Abernethy. 1999. Surveys of fall chinook salmon spawning downstream of Lower Snake River hydroelectric projects. Summary Report for 1993-1998. Prepared for U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington by Pacific Northwest Laboratory, Richland, WA.

Hymer, J. 1997. Results of studies on chinook spawning in the mainstem Columbia River below Bonneville Dam. Columbia River Progress Report 97-9. Washington Department of Fish and Wildlife. Battle Ground, WA.

Visser, R.H., 1999. Utilizing remotely sensed imagery and GIS to monitor and research salmon spawning: A case study of the Hanford Reach fall chinook (*Oncorhynchus tshawytscha*). Masters Thesis. Central Washington State University. Ellensberg, WA.

Appendix A

PNNL Redd Coordinate Description

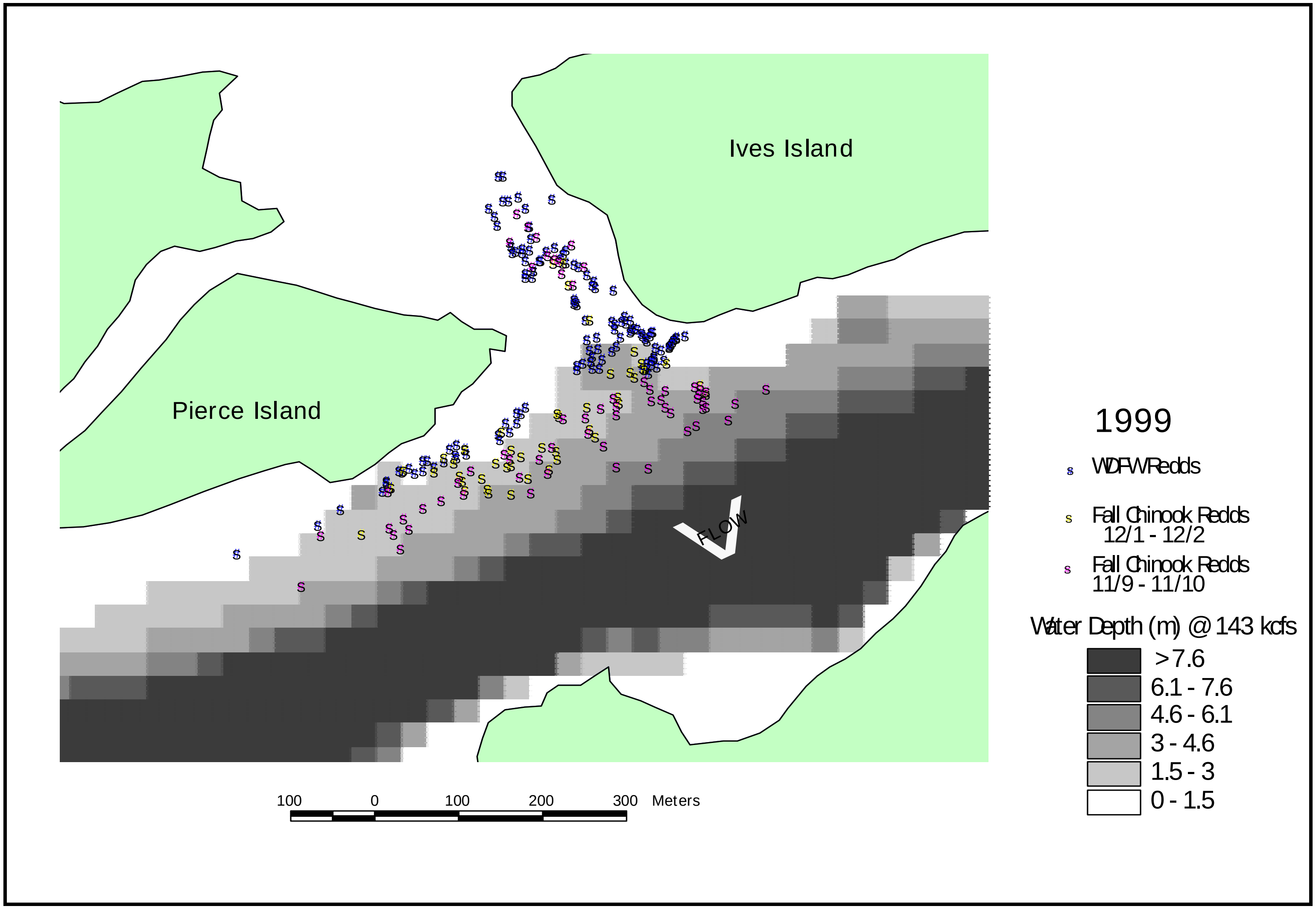
Projection	Stateplane
Zone	5626
Datum	NAD27
Units	Meters
Vertical Datum	NGVD29

	NORTHING	EASTING		NORTHING	EASTING
1	107482	1615670	34	107697	1615902
2	107696	1615747	35	107896	1616021
3	107642	1616060	36	107966	1616069
4	107698	1616030	37	107961	1616189
5	107728	1616013	38	107923	1616301
6	107881	1616006	39	107944	1616288
7	107763	1616067	40	107998	1616263
8	107722	1616090	41	108025	1616229
9	107810	1616146	42	108057	1616309
10	107844	1616218	43	107933	1616376
11	107868	1616305	44	107893	1616395
12	107917	1616281	45	107875	1616404
13	107966	1616332	46	107867	1616489
14	108039	1616461	47	108001	1616432
15	108016	1616487	48	108130	1616449
16	107941	1616524	49	108056	1616488
17	107874	1616565	50	107936	1616558
18	107959	1616630	51	107973	1616638
19	108015	1616597	52	108049	1616665
20	108066	1616649	53	108018	1616673
21	108184	1616693	54	108200	1616678
22	107984	1616902	55	108211	1616670
23	108228	1616841	56	108141	1616794
24	108273	1616889	57	108473	1616974
25	108242	1616900	58	108423	1617001
26	108346	1617008	59	108397	1617009
27	108311	1617033	60	108363	1616974
28	108269	1617077	61	108384	1616954
29	108309	1617092	62	108845	1616652
30	108213	1617112	63	108845	1616692
31	108235	1617093	64	108748	1616712
32	108229	1617240	65	108604	1616796
33	108311	1617230	66	108379	1616879

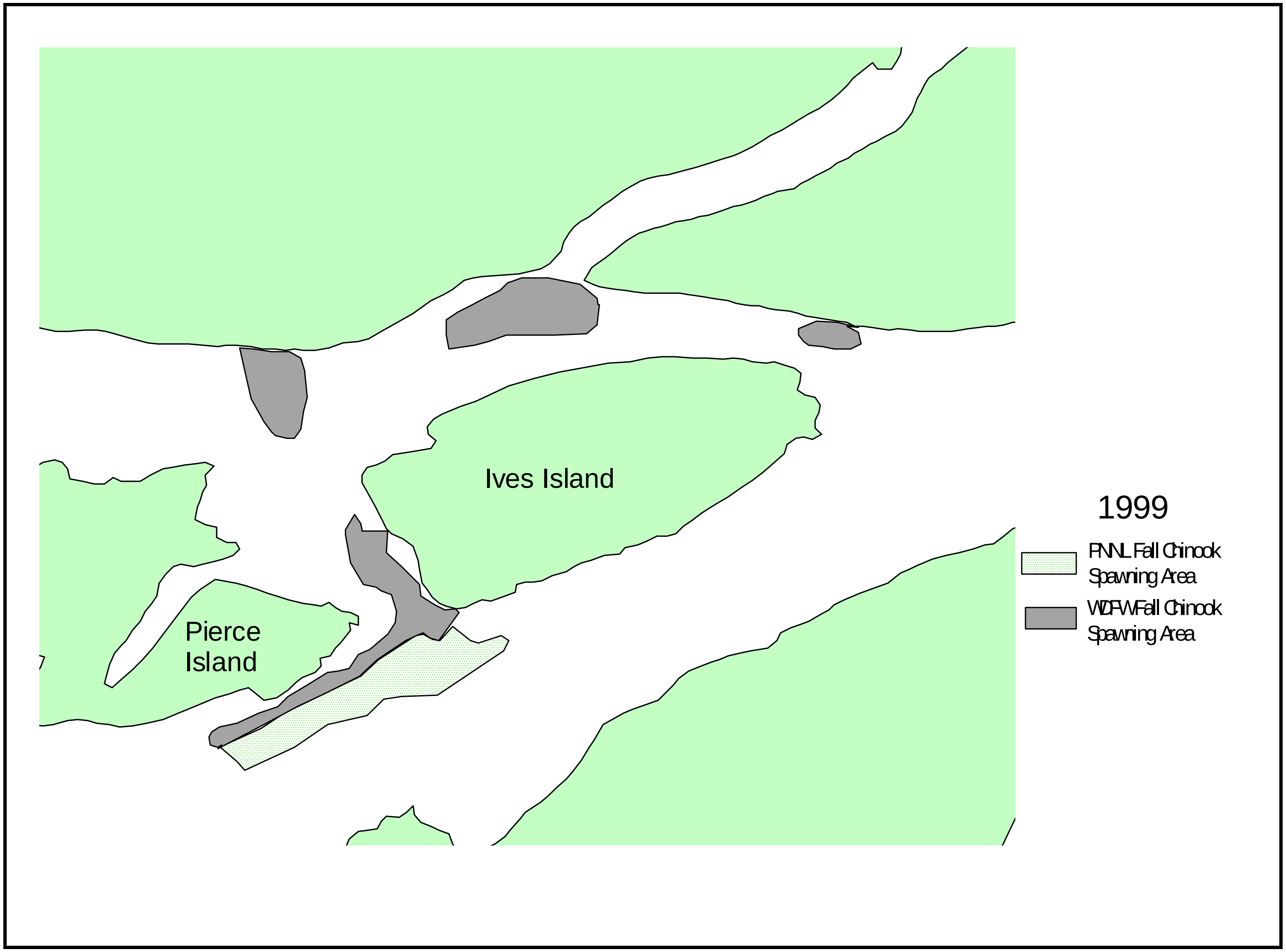
	NORTHING	EASTING		NORTHING	EASTING
67	108262	1617242	96	108110	1616817
68	108238	1617252	97	108421	1617098
69	108274	1617218	98	108327	1617230
70	108289	1617222	99	108288	1617250
71	108261	1617038	100	107884	1616308
72	108301	1617248	101	107982	1616475
73	108326	1617208	102	107991	1616491
74	108180	1617337	103	108028	1616527
75	108255	1617366	104	108065	1616609
76	108311	1617487	105	108278	1616907
77	108918	1616724	106	108250	1616913
78	108826	1616775	107	108236	1616787
79	109053	1616514			
80	108999	1616557			
81	108954	1616591			
82	108878	1616633			
83	108861	1616658			
84	108847	1616675			
85	108797	1616687			
86	108748	1616732			
87	108933	1616486			
88	108825	1616571			
89	108191	1616779			
90	108125	1616792			
91	108201	1616898			
92	108070	1616853			
93	107977	1617027			
94	108160	1617211			
95	108137	1617180			

APPENDIX B

Maps Illustrating Fall Chinook Redd Locations and Spawning Areas Below Bonneville Dam



Location of fall chinook salmon redds mapped by WDFW and PNNL in the mainstem of the Columbia River below Bonneville Dam in 1999.



Spatial extent of fall chinook salmon spawning areas mapped by WDFW and PNNL near the main channel of the Columbia River